



- (19) Japan Patent Office (JP)
- (12) Publication of Patent Application (A)
- (11) Publication Number of Patent Application: Hei-3-249291
- (43) Date of Publication of Application: November 7, 1991
- (51) Int. Cl.⁵ Identification No. Intraoffice Reference
Number
D 21 C 5/02 8118-4L
C 12 S 3/08 7803-4B

Request for Examination: not made

Number of Claims: 1 (8 pages in total)

- (21) Application Number: Hei-2-42274
- (22) Application Date: February 22, 1990
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SPECIFICATION

1. Title of the Invention

Method for Deinking Waste Paper

2. Claim

(1) A method for deinking waste paper by adding a deinking agent to a solution for treating waste paper to separate ink from waste paper, characterized in that a deinking agent which cannot be hydrolyzed with esterase and a deinking agent which can be hydrolyzed with esterase are used and esterase is used in combination, to hydrolyze the deinking agent which can be hydrolyzed with esterase.

3. Detailed Description of the Invention

[Industrial Field of the Invention]

The present invention relates to a method for deinking waste paper for separating ink from waste paper in the production of deinked waste paper pulp.

[Related Art]

It is necessary to deink printed waste paper so as to obtain regenerated pulp from waste paper. The method for deinking printed waste paper includes for example a rinse process including a step of digesting waste paper with alkali chemicals such as sodium hydroxide and sodium silicate and deinking agents (surfactants) in a globe digester at high temperature and high pressure and a step of passing the digested product through wire lattices of for example decker, extractor and slope screen

to remove ink particles; a modification process thereof, which includes a step of thermally treating waste paper with alkali chemicals and deinking agents in a pulper at 50 to 60°C and a step of carrying out the same procedures as in the rinse process for the resulting digested product to remove ink particles; and a floatation process including a step of treating water paper with alkali chemicals and deinking agents in a pulper and a subsequent step of purging air into the treated solution to attach ink to the resulting foam for deinking. In case of the floatation process, for example, the following steps are carried out: maceration, dehydration, high-concentration maceration, aging, floatation, and rinsing on completion. However, some of the steps may sometimes be skipped.

Depending on the individual steps, different functions are demanded for deinking agents. For example, the maceration step requires deinking agents to have functions such as permeation into fiber, ink emulsification and dispersion, and the prevention of the reattachment of separated ink to fiber; the dehydration step requires deinking agents to have functions such as ink dispersion and the prevention of the reattachment of ink to fiber; the high-concentration maceration step requires deinking agents to have functions such as the prevention of the reattachment of ink to fiber; the aging step requires deinking agents to have functions such as the prevention of the reattachment of ink to fiber and ink aggregation; the floatation step requires

deinking agents to have functions such as ink aggregation and foaming, and the prevention of the reattachment of ink to fiber; and the rinsing step requires deinking agents to have functions such as ink dispersion and defoaming.

For the deinking agents in the related art for any of the processes, use is made of anionic surfactants such as fatty acids and salts thereof, and alkyl-sulfate; nonionic surfactants such as higher alcohol ethylene oxide propylene oxide adduct and fatty acid ethylene oxide propylene oxide adduct; and mixtures thereof.

Although fatty acids and salts thereof have great ink aggregation potencies and high ink removal potencies to aggregate and discharge ink together with foam at the floatation process, however, they have poor potencies of ink separation from waste paper, involving a larger amount of remaining ink, disadvantageously. Because the foaming potencies thereof required for the floatation process are low, disadvantageously, it is required to additionally add foaming agents.

Meanwhile, nonionic surfactants such as higher alcohol ethylene oxide propylene oxide adduct and fatty acid ethylene oxide propylene oxide adduct have great ink separation potencies and high potencies to prevent the reattachment thereof, but the ink removal potencies are not sufficient, disadvantageously. Additionally because these nonionic surfactants involve much foaming, disadvantageously, foam troubles may occur during the

rinsing step, the paper step using deinked waste paper pulp as a raw material, and the liquid waste disposal step.

So as to overcome these problems, a proposition of deinking with a combination of fatty acid alkylene oxide adducts and esterase is made (JP-A-1-48198). The process is a process of adding a fatty acid alkylene oxide adduct to a solution for treating waste paper and adding esterase to the resulting mixture. By the process, the ink aggregation potency is enhanced to thereby improve the deinking effect, to obtain deinked waste paper pulp at a higher whitening degree. By the process, additionally, foaming can be suppressed at the rinsing step, the paper step and the liquid waste disposal step. However, the process has the following problems.

<1> In case that fatty acid alkylene oxide adducts are completely decomposed, the ink having been emulsified attaches again to pulp, to lower the whitening degree.

<2> The ink separation potencies of fatty acid alkylene oxide adducts is poorer, compared with higher alcohol alkylene oxide adducts or alkyl-phenol alkylene oxide adducts.

<3> It is very difficult to control the decomposition ratio of fatty acid alkylene oxide adducts with esterase during the deinking step. The ratio of fatty acid alkylene oxide adducts and the resulting decomposed fatty acids cannot be retained at an optimal ratio.

[Problems that the Invention is to Solve]

So as to solve the problems, it is an object of the invention to provide a method for deinking waste paper, which can advantageously solve foam troubles during the rinsing step, the paper step and the liquid waste disposal step and can also enhance the ink separation potencies to further raise the whitening degree, so that high-quality deinked waste paper pulp can readily be obtained.

[Means for Solving the Problems]

The invention relates to a method for deinking waste paper by adding a deinking agent to a solution for treating waste paper to separate ink from waste paper, characterized in that a deinking agent which cannot be hydrolyzed with esterase and a deinking agent which can be hydrolyzed with esterase are used and esterase is used in combination, to hydrolyze the deinking agent which can be hydrolyzed with esterase.

As the deinking agent which cannot be hydrolyzed with esterase (sometimes referred to as non-hydrolysable deinking agent hereinbelow) in accordance with the invention, a surfactant which cannot be hydrolyzed with esterase can be used, including for example an ether-type alkylene oxide adduct represented by the following general formula [I]:



(in the formula, R^1 represents an alkyl group or alkenyl group

with 8 to 24 carbon atoms, or an alkyl-phenyl group where phenyl group is substituted with an alkyl group with 4 to 18 carbon atoms; (A^1O) represents an oxyalkylene group with 2 to 4 carbon atoms and may be in random addition, block addition or any combination of them; and m represents an integer of 1 or more.)

In compounds of the general formula [I] or the general formula [II] described below, one alkylene oxide type or plural alkylene oxides may be added in (A^1O) or (A^2O). When plural alkylene oxides are added, the forms of these individual alkylene oxides being added are not specifically limited but include random adducts where alkylene oxides are randomly added, block adducts where alkylene oxides are added in blocks or adducts of a combination of them.

The ether-type alkylene oxide adduct represented by the general formula [I] specifically includes for example higher alcohol alkylene oxide adducts such as $C_{12}H_{23}O(EO)_{20}(PO)_7H$ (block adduct; EO represents oxyethylene group and PO represents oxypropylene group; the same is true hereinbelow),

$C_{26}H_{33}O(EO)_{40}(PO)_{20}H$ (random adduct),

$C_{13}H_{27}O(EO)_{20}(PO)_{20}H$ (random adduct), and

$C_{13}H_{37}(EO)_{25}(PO)_{25}H$; (random adduct)

and alkyl-phenol alkylene oxide adducts such as

C_9H_{18} -phenylene- $O(EO)_{25}(PO)_{20}H$ (random adduct).

Because the ether-type alkylene oxide adduct represented by the general formula [I] has a great ink separation potency

and a marked property for preventing ink reattachment, the ether-type alkylene oxide adduct can preferably be used.

The ether-type alkylene oxide adduct represented by the general formula [I] can be produced by adding alkylene oxide to the corresponding alcohol or phenol, randomly or in an optional order.

In accordance with the invention, ester-type surfactants which can be decomposed by esterase can be used as the deinking agent which can be hydrolyzed by esterase (sometimes referred to as hydrolysable deinking agent hereinbelow). The deinking agent includes for example fatty acid ester-based surfactants represented by the following general formulas [II] and [III].

[II]

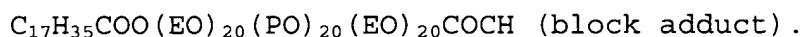
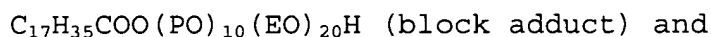
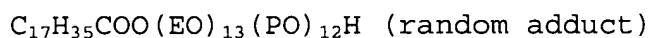
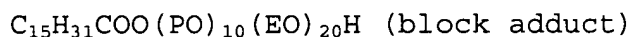
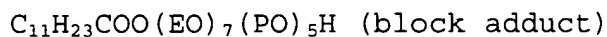
(In the formula, R^2 represents an alkyl group or alkenyl group with 7 to 23 carbon atoms; R^3 represents hydrogen atom or an alkyl group, alkenyl group or acyl group with one to 22 carbon atoms; (A^2O) represents an oxyalkylene group with 2 to 4 carbon atoms and may be in any form of random adduct, block adduct and combinations thereof; n represents a numerical figure of 1 or more.)

[III]

(In the formula, R^4 represents an alkyl group or alkenyl group with 3 to 29 carbon atoms, particularly preferably 11 to 23 carbon atoms; R^5 represents an alkyl group or alkenyl group with one to 10 carbon atoms, particularly preferably a branched alkyl group or alkenyl group with one to 10 carbon atoms.)

Among the two, the fatty acid alkylene oxide adduct represented by the general formula [II] is preferably used.

The fatty acid alkylene oxide adduct represented by the general formula [II] specifically includes for example



The fatty acid alkylene oxide adduct represented by the general formula [II] can be produced by adding alkylene oxide to the corresponding carboxylic acid, randomly or in an optional order.

As the esterase for use in accordance with the invention, any esterase capable of hydrolyzing ester bonds in the hydrolyzable deinking agent is satisfactory with no specific limitation and includes for example allyl esterase, carboxyl esterase and lipase. Among them, lipase heat-resistant and alkali-resistant is preferable. Any commercially available

esterase may be used. Additionally, esterase immobilized on an appropriate carrier may also be used.

According to the deinking method of the invention, the hydrolyzable deinking agent can be added to a solution for treating waste paper, before the addition of esterase or simultaneously with the addition of esterase. Preferably, however, the deinking agent is added before the addition of esterase. Meanwhile, the non-hydrolyzable deinking agent is satisfactorily added at the time of ink separation from waste paper, and may be added at any time before esterase addition, simultaneously with esterase addition or after esterase addition. Preferably, the non-hydrolyzable deinking agent is added before esterase addition. The non-hydrolyzable deinking agent and the hydrolyzable deinking agent may be added at the total intended amounts in one portion, or at plural times in some portions. Esterase may also be added at the total intended amount in one portion, or at plural times in some portions.

The non-hydrolyzable deinking agent is added at an amount of 0.001 to 2 % by weight, preferably 0.01 to 0.5 % by weight of the weight of waste paper. The hydrolyzable deinking agent is added at an amount of 0.001 to 2 % by weight, preferably 0.01 to 0.5 % by weight of the weight of waste paper. The non-hydrolyzable deinking agent and the hydrolyzable deinking agent are preferably used at a weight ratio such that the weight ratio of the non-hydrolyzable deinking agent to the hydrolyzable

deinking agent is 1/9 to 9/1, preferably 8/2 to 2/8.

The esterase is added at an amount of 500 U/kg-waste paper or more, preferably 1000 U/kg-waste paper or more. Herein, 1 U (U: unit) means an enzyme amount measured by the following method of assaying enzyme activity. Preferably, esterase is added under a condition for enhancing the enzyme activity. When a heat-resistant esterase is used, for example, the esterase is preferably added at a temperature around 50°C and around pH 8. Further, esterase may be added in a powder form or may be added after dissolution in water or buffers.

The method of the invention can be applied to known deinking processes such as floatation process and rinse process. The deinking step in the floatation process is now described below, when the method of the invention is applied to the floatation process.

The non-hydrolyzable deinking agent and the hydrolyzable deinking agent may be added individually at an appropriate time before floatation, for example maceration step, dehydration step, high-concentration maceration step or aging step. Preferably, these deinking agents are added at maceration step or high-concentration maceration step.

Esterase can be added simultaneously with the addition of the hydrolyzable deinking agent or at an appropriate time after the addition of the hydrolyzable deinking agent, for example at maceration step, dehydration step, or high-concentration

maceration step, before or during aging a solution of deinking-treated waste paper, at dilution step of aged pulp, before floatation, before rinsing step, or in final chest or in machine chest. Preferably, esterase is added at the dilution step of aged pulp.

Deinking to be carried out in the flow of pulper, thickener, kneader, tower, chest, floatater, and extractor is now exemplified. Preferably, the non-hydrolyzable deinking agent and the hydrolyzable deinking agent are added to pulper, kneader or tower, while esterase is added to chest.

The deinking process in the rinse process is now described, when the method of the invention is applied to the rinse process.

The non-hydrolyzable deinking agent and the hydrolyzable deinking agent are individually added at an appropriate time before rinsing, for example at maceration step, dehydration step, high-concentration maceration step, or aging step. Preferably, these deinking agents are added at maceration step or high-concentration maceration step.

Esterase can be added simultaneously with the addition of the hydrolyzable deinking agent or at an appropriate time after the addition of the hydrolyzable deinking agent, for example at maceration step, dehydration step or high-concentration maceration step, before or during aging a solution of deinking-treated waste paper, at dilution step of aged pulp, or before rinsing step. Preferably, esterase is added at the

dilution step of aged pulp.

Deinking to be carried out in the flow of pulper, concentration cylinder press, tower, chest, and rinse extractor is now exemplified. Preferably, the non-hydrolyzable deinking agent and the hydrolyzable deinking agent are preferably added to pulper, while esterase is added to tower or chest.

For the method of the invention, there can be used sodium hydroxide, sodium silicate, sodium sulfite, hydrogen peroxide, calcium chloride, foaming agents and chelators other than both the deinking agents and esterase.

Because the higher alcohol alkylene oxide adduct or the alkyl-phenol alkylene oxide adduct with excellent ink separation potencies can be used as the deinking agent for the method of the invention, the amount of the remaining ink never separated from waste paper can be reduced. The reattachment of ink can be prevented by allowing the non-hydrolyzable deinking agent which cannot be hydrolyzed with esterase, to exist in the solution for treating waste paper, even when the hydrolyzable deinking agent is completely decomposed. Thus, the method of the invention causes less ink residue compared with the methods using hydrolyzable deinking agents and esterase, to enhance the whitening degree to thereby obtain high-quality deinked waste paper pulp.

Because both the non-hydrolyzable deinking agent and the hydrolyzable deinking agent are used as the deinking agent in

accordance with the invention, the ratio of the deinking agents to the fatty acid derived from the hydrolysis of the hydrolyzable deinking agent can be controlled with the ratio of the non-hydrolyzable deinking agent and the hydrolyzable deinking agent for use. Therefore, it is not necessary to control the decomposition ratio of the hydrolyzable deinking agent. According to the method of the invention, thus, high-quality deinked waste paper pulp with a higher whitening degree can be readily obtained, compared with the methods using hydrolyzable deinking agents and esterase.

In accordance with the invention, esterase is added to partially or wholly hydrolyze the hydrolyzable deinking agent, to release fatty acids with excellent ink aggregation potencies to effectively carry out ink aggregation and additionally to suppress foaming at the steps after esterase addition. Compared with the methods singly using higher alcohol alkylene oxide adducts or alkyl-phenol alkylene oxide adducts with excellent ink separation potencies, thus, the method of the invention can solve troubles due to foaming, so that the elevation of rinse efficiency, the resolution of foaming troubles at the paper step and the improvement of SS precipitation at the liquid waste disposal step can be attained, for example.

[Advantages of the Invention]

In accordance with the invention, the method for deinking waste paper by adding a deinking agent to a solution for treating

waste paper to separate ink from waste paper includes a step of using esterase in combination with a deinking agent which cannot be hydrolyzed with esterase and a deinking agent which can be hydrolyzed with esterase, to allow the esterase to hydrolyze the deinking agent which can be hydrolyzed with esterase. Therefore, foaming troubles at the rinsing step, paper step, and liquid waste disposal step can be overcome, while the ink separation potency can be enhanced to raise the whitening degree more highly. High-quality deinked waste paper pulp can thereby be obtained readily.

[Examples]

Examples of the invention are now described.

Examples 1 and 2

(1) Maceration of waste paper

Waste paper containing newspaper pieces of Mainichi Shimbun, Asahi Shimbun and Yomiuri Shimbun (all within one to 2 months after printing) at 80 % by weight and advertisement paper at 20 % by weight was cut into pieces with a turbo cutter. The resulting pieces were mixed together. To 70 g of the pieces were added 10.5 g of aqueous 10 wt % of sodium hydroxide solution, 21 g of aqueous 10 wt % sodium silicate (No. 3) solution, 7 g of aqueous 30 wt % hydrogen peroxide, 28 g of a given concentration of an aqueous deinking agent solution and 1265 g of water, to adjust the waste paper concentration to 5 % by weight. The resulting mixture was treated with a 3-liter hydropulper (3,000

rpm) at 55°C for 20 minutes, followed by addition of 932 g of water to dilute the mixture to a waste paper concentration of 3 % by weight, for 5-min agitation for complete maceration. Then, aluminium sulfate $[\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}]$ was added to the completely macerated waste paper to adjust the pH to pH 9.0, followed by addition of an enzyme (lipase from *Pseudomonas* sp. KWI-56; manufactured by Kurita Water Industries Ltd.). The resulting mixture was kept warm at 50°C for a given period of time. Subsequently, 4666 g of water was added to dilute the mixture to a waste paper concentration of 1 % by weight. Ink was removed from the resulting sample by the following processes.

(2) Ink removal

(A) Flootation process (Example 1)

The sample in (1) was injected in a 5-liter Voith floatater, for 10-min suspension treatment. Removing the carbon aggregate in the upper layer, the resulting sample was manually papered with a TAPPI standard sheet machine, to obtain a pulp sheet. The pulp sheet was used for evaluation of the deinking effect by the following evaluation method. The results are shown in Table 1.

(B) Rinse process (Example 2)

The sample in (1) was filtered through a 80-mesh sieve, to which water was added to a regenerated pulp concentration of 1 % by weight. The resulting solution was again filtered through a 80-mesh sieve to remove carbon.

Water was added to regenerated pulp after completion of rinsing to a pulp concentration of 1 % by weight, for manual papering with a TAPPI standard sheet machine to obtain a pulp sheet. The pulp sheet was evaluated of the deinking effect in the same manner as in the floatation process. The results are shown in Table 2.

Evaluation method of deinking effect

(a) Whitening degree

Reflectance was measured with a photoreflexion meter, based on the definition that the reflectance of magnesium oxide was 100. The numerical figures in Tables 1 and 2 express mean of the values of 5 sheets measured at 5 points.

(b) Number of remaining ink spots

The remaining ink spots were counted with a microscope $\times 40$ and were then corrected to the numerical figure per 1 cm^2 .

Additionally, the enzyme activity was assayed by the following method.

Assaying method of enzyme activity

The rotation agitation method was used. Specifically, 5 ml of 50 mM phosphate buffer, pH 6.5, 1 ml of a substrate and 0.1 ml of an enzyme solution were placed in a reaction container of a 32-mm diameter and a 76-mm height, where the mixture was agitated at 520 rpm with a magnetic stirrer in an incubator at 37°C , for reaction for a given period of time. After reaction, 20 ml of ethanol was added to terminate the enzyme reaction.

The extracted free fatty acids were titrated with 1/20 N KOH solution to pH 10.0.

Enzyme activity (U; unit) was defined as follows. 1U of an enzyme can release 1 μ mol fatty acids from a substrate olive oil per one minute under the following reaction conditions. The activity (U/ml) of the enzyme solution can be determined by the following formula.

Enzyme activity (U/ml) = [Titration value (ml) - blank value (ml)] \times 50 / [reaction period of time (min) \times 0.1 (ml)]

Blank prepared by ethanol addition and subsequent addition of the enzyme solution was similarly titrated.

Comparative Examples 1 and 2

These Comparative Examples were carried out in the same manner of the waste-paper maceration step as in Examples 1 and 2, except for the use of deinking agents shown in Table 1 or 2. In case that a non-hydrolyzable deinking agent was used alone, herein, no enzyme was added. The results of the floatation process (Comparative Example 1) are shown in Table 1, while the results of the rinse process (Comparative Example 2) are shown in Table 2.

Table 1

	Test No.	Non-hydrolyzable deinking agent			Hydrolyzable deinking agent			Amount of esterase added *4	Time period after esterase addition (in minute)	Whitening degree (%)	Number of remaining ink spots (spots/cm ²)
		Structure *1	Form in addition *2	Amount added *3	Structure *1	Form in addition *2	Amount added *3				
Example 1	1		B	0.1		R	0.3	10000	30	54.2	10
	2		R	0.2		B	0.2	6000	30	54.8	6
	3		"	0.2		"	0.2	6000	60	55.0	5
	4		R	0.3		B	0.1	4000	30	53.9	11
	5		R	0.04		-	0.36	6000	30	53.8	14
	6		R	0.36		B	0.04	1000	30	54.1	11
Comparative Example 1	1		-	-		R	0.4	10000	30	52.7	29
	2		-	-		B	0.4	6000	30	53.0	27
	3		-	-		"	0.4	6000	60	49.1	68
	4		-	-		B	0.4	4000	30	52.2	36
	5		-	-		-	0.4	6000	30	51.9	33
	6		-	-		B	0.4	1000	30	52.5	31
	7		B	0.4		-	-	-	-	50.7	21
	8		R	0.4		-	-	-	-	51.5	15
	9		R	0.4		-	-	-	-	51.2	17
	10		R	0.4		-	-	-	-	51.0	16

*1) EO: oxyethylene group; PO: oxypropylene group

*2) B: block adduct; R: random adduct

*3) In the unit "% by weight" to waste paper

*4) In the unit "U/kg-waste paper"

Table 2

	Test No.	Non-hydrolyzable deinking agent			Hydrolyzable deinking agent			Amount of esterase added *4	Time period after esterase addition (in minute)	Whitening degree (%)	Number of remaining ink spots (spots/cm ²)
		Structure *1	Form in addition *2	Amount added *3	Structure *1	Form in addition *2	Amount added *3				
Example 2	1		B	0.1		R	0.3	10000	30	53.6	13
	2		R	0.2		B	0.2	6000	30	54.1	8
	3		"	0.2		"	0.2	6000	60	54.6	6
	4		R	0.3		B	0.1	4000	30	53.0	12
	5		R	0.04		-	0.36	6000	30	53.1	16
	6		R	0.36		B	0.04	1000	30	53.3	11
Comparative Example 2	1		-	-		R	0.4	10000	30	51.9	33
	2		-	-		B	0.4	6000	30	52.4	32
	3		-	-		"	0.4	6000	60	48.6	75
	4		-	-		B	0.4	4000	30	51.0	40
	5		-	-		-	0.4	6000	30	50.9	41
	6		-	-		B	0.4	1000	30	51.1	36
	7		B	0.4		-	-	-	-	51.3	25
	8		R	0.4		-	-	-	-	52.1	22
	9		R	0.4		-	-	-	-	51.6	27
	10		R	0.4		-	-	-	-	52.0	21

*1) EO: oxyethylene group; PO: oxypropylene group

*2) B: block adduct; R: random adduct

*3) In the unit "% by weight" to waste paper

*4) In the unit "U/kg-waste paper"

The results from the floatation process as shown in Table 1 show that the whitening degree in the Example of the invention using the non-hydrolyzable deinking agents, the hydrolyzable deinking agents and esterase is improved and the number of remaining ink spots therein is smaller, compared with the Comparative Example involving lower whitening degrees and larger numbers of remaining ink spots. Thus, high-quality deinked waste paper pulp can be obtained in the Example. When the hydrolyzable deinking agents and esterase are used, additionally, the hydrolyzable deinking agents are completely decomposed 60 minutes after esterase addition, causing the reattachment of ink and involving lower whitening degrees (Comparative Example 1, Test Nos. 2 and 3). Compared with the above case, greater results can be obtained independent on the time period after esterase addition, according to the invention using the non-hydrolyzable deinking agents, the hydrolyzable deinking agents and esterase (Example 1, Test Nos. 2 and 3).

The results of the rinse process in Table 2 show that the same results as in the floatation process can also be obtained by the rinse process.

Example 3

Waste paper of newspaper was deinked, using test machines in the flow of pulper, thickener, kneader, tower, chest, floatater, and extractor.

As inorganic chemicals, sodium hydroxide at 1.5 % by weight (to waste paper) and sodium silicate No.3 at 3 % by weight (to waste paper) were added to pulper, while hydrogen peroxide was added at 1 % by weight (to waste paper) to tower. As a non-hydrolyzable deinking agent, further, $C_{18}H_{37}O(EO)_{20}(PO)_{10}H$ (random adduct) was added at 0.2 % by weight (to waste paper) to pulper. As a hydrolyzable deinking agent, $C_{15}H_{32}COO(PO)_{30}(EO)_{20}H$ (block adduct) was added to 0.2 % by weight (to waste paper) to pulper. As esterase, lipase derived from *Pseudomonas* sp. KWI-56 (manufactured by Kurita Water Industries Ltd.) was added at a ratio of 6,000 U/kg-waste paper to chest before floatater. Then, the whitening degree of deinked pulp after extractor was measured over time by the same method as in Example 1. The results are shown in Fig. 1.

Comparative Example 3

Except for no addition of $C_{18}H_{37}O(EO)_{20}(PO)_{10}H$ (random adduct) and addition of 0.4 % by weight of $C_{15}H_{31}COO(PO)_{10}(EO)_{20}H$ (block adduct) (to waste paper) to pulper, the same procedures as in Example 3 were carried out. The results are shown in Fig. 1.

The results in Fig. 1 indicate that a stable deinking effect with a whitening degree within a range of 55 to 56 % can be obtained in Example 3, but the deinking effect in Comparative Example 3 is variable with a change of the whitening degree from 52 to 55 %.

The reason of the occurrence of the variation of the deinking effect in Comparative Example 3 may be as follows. The retention time of esterase in the reaction chest is not constant, so that the hydrolysis of $C_{15}H_{31}COO(PO)_{10}(EO)_{20}H$ progresses in case of a longer reaction time, involving the disappearance of the emulsification of ink separated from waste paper. Thus, ink reattachment to pulp occurs involving the lower whitening degree. In Example 3, meanwhile, $C_{18}H_{37}O(EO)_{20}(PO)_{10}H$ which cannot be decomposed with esterase exists in the treated solution. Even when the retention time of esterase in chest changes to cause the change of the decomposition ratio of the co-existing $C_{15}H_{31}COO(PO)_{30}(EO)_{20}H$, therefore, the total ink emulsification potency of the deinking agents never disappears. Thus, such stable deinking effect can be obtained.

4. Brief Description of Drawings

Fig. 1 shows the graphs depicting the results in Example 3 and Comparative Example 3.

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Fig. 1

Whitening degree (%)

Time period (in hour)

Example 3

Comparative Example 3